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ABSTRACT

The hypotheses that interpersonal learning is more effective than individual learning in nonlinear tasks but that students learn relatively less from their teachers when the teachers have to teach a complex nonlinear rule than when they have to teach a simple linear rule was tested in an experiment following the social judgment theory interpersonal learning paradigm. A 2 x 3 x 4 factorial design was employed: (learning tasks: linear vs. nonlinear) by (learning conditions: teachers, who already knew the task, vs. learners, who had to learn the task from the teachers, vs. individual learners, who had to learn the task from outcome feedback from the task) by (blocks of trials). The results supported both hypotheses: the subjects learned the nonlinear task much better in the interpersonal learning conditions than in the individual learning conditions, but for the linear task, there was very little difference between the two learning conditions. Results also indicated that learners approached the same level of performance as their teachers at a slower rate in the nonlinear conditions than in the linear conditions. (Author/RD)

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CAN A PERSON TEACH ALL HE KNOWS? EVIDENCE FROM INTERPERSONAL LEARNING OF INDUCTIVE INFERENCE TASKS

Andersson, H., and Brehmer, B. Can a person teach all he knows? Evidence from interpersonal learning of inductive inference tasks. Umeå Psychological Reports No. 142, 1978. - The hypotheses that, (a) interpersonal learning is more effective than individual learning in nonlinear tasks but that (b) the subjects learn relatively less from their teachers when the teachers have to teach a complex nonlinear rule than when they have to teach a simple linear rule was tested in an experiment following the Social Judgment Theory interpersonal learning paradigm and employing a 2 (learning tasks: linear vs. nonlinear) by 3 (learning conditions: teachers, who already knew the task, vs. learners, who had to learn the task from the teachers, vs. individual learners, who had to learn the task from outcome feedback from the task) by 4 (blocks of trials) factorial design. The results supported both hypothesis in that (a) the subjects learned the nonlinear task much better in the interpersonal learning conditions, than in the individual learning conditions, but for the linear task, there was very little difference between the two learning conditions, and (b) the learners approached the same level of performance as their teachers at a slower rate in the nonlinear conditions than in the linear conditions.

A basic assumption in our common sense understanding of teaching is that if a person knows something, he is also able to teach what he knows to another person. Some people may be better at this than other people, but differences in this regard are generally seen as less important.

This may be true for many kinds of tasks, but there is reason to question the assumption for tasks which require persons to make inductive inferences. For these kinds of tasks, it is important to distinguish between two kinds of knowledge about the task: predictive knowledge, which refers to a person's ability to make correct judgments, and descriptive knowledge, which refers to his ability to describe the task, and thus how he goes about making his judgments. Evidence for the importance of this distinction comes from two kinds of studies.

The first kind of studies are those concerned with the relation between objective and subjective descriptions of judgment which show that judgment processes as described by the judge himself may differ considerably from the judgment processes implied by the actual judgments (see, e.g., Slovic & Lichtenstein, 1971). These results suggest that the sources of predictive knowledge are different from those of descriptive knowledge.

The second kind of studies are those concerned with subjects' ability to use information about a judgment task for making actual judgments (see, e.g., Brehmer, 1976, for a summary of results). These studies show that the actual judgments made by a subject may deviate in systematic ways from those he should be making, given his knowledge about the task.

For judgment tasks, then, there is reason to believe that a teacher may not be able to teach another person all he knows. Specifically, he may be able to communicate his descriptive knowledge, but that does not mean that the pupil will have the same level of predictive knowledge as his teacher, because the teacher's descriptive knowledge may very well differ from his predictive knowledge. In addition, the results obtained in the studies referred to above lead us to expect that the extent to which a teacher can communicate what he knows will vary with the nature of the task. Specifically, the results suggest

that non-linear judgment policies are described less accurately than linear judgment policies (Brehmer, Kuylenstierna, & Liljergren, 1974). This suggests that a teacher should be less able to teach all he knows about a non-linear task than about a linear task. Interpersonal learning should therefore be less efficient in the former case than in the latter case. However, non-linear tasks are generally harder to learn than linear tasks, (Brehmer, 1974) and interpersonal learning conditions have been found to be more superior to individual learning conditions for nonlinear tasks than for linear tasks (Earle, 1973). Thus, we arrive at the somewhat paradoxical prediction that although subjects should benefit more from a teacher in a non-linear task than in a linear task, he will nevertheless learn relatively less from his teacher in the former task than in the latter, i.e., there should be a greater difference between teachers and learners in non-linear conditions than in linear conditions. This experiment was designed to test these hypotheses.

METHOD

Subjects. The subjects, 48 in all, were undergraduate students from the University of Umeå and students, aged around 18, from a high school in Umeå. They were paid to serve as subjects.

Learning tasks. Two kinds of learning tasks were used. One was a linear inference task where the relations between cues and criterion was a positive linear function. The other was a non-linear inference task where the relations between the cues and the criterion was a U-shaped function. For both tasks the inter-correlations between cues were zero and each cue-criterion correlation was equal to .68 leading to a multiple correlation of $R = .96$ for both tasks.

The tasks were presented in booklets with the cues in the form of bars where the height of the bars indicated the cue value. These ranged from 1 through 15. The criterion values were given as numbers at the back of each page and ranged from 1 through 40.

Design. Two variables were systematically manipulated in the experiment: The learning task and the learning conditions. There were two learning tasks as described above and three learning conditions. The first learning condition, the IPL-teacher condition, comprises the subjects who were informed of the nature of the task and trained before the IPL session. These subjects were supposed to serve as teachers to the subjects in the second condition, the IPL learner condition (IPL-conditions), which consists of those subjects who were not trained before the IPL stage. The third condition, the task learning condition (TL) was an individual learning condition in which subject learned their tasks from outcome feedback from the task. In each condition, four blocks of fifteen trials each were given.

The experimental design thus was a 3 (learning conditions: IPL-teacher vs. IPL vs. TL) by 2 (learning tasks: linear vs. non-linear task) by 4 (blocks of learning) factorial design with repeated measures on the last factor.

Procedure. When subjects arrived they were randomly assigned to the experimental conditions. Those assigned to be teachers first went through an individual training stage in which they received 75 trials of training on an inductive inference task that was formally identical to that they later were to solve together with another subject. On each trial they first (1) observed the cue values and made an individual prediction which they recorded on a special form and finally turned the page to observe the criterion value. At the end of training cue-criterion correlations were computed for the last fifteen trials. Subjects

who had cue correlations higher than $r_{xis} = .50$ for both cues and for whom these correlations did not differ significantly, were accepted for the experiment. Those who failed were given another 30 trials after which their correlations were computed again. When the teachers had mastered their training task they were informed about this and brought together with a subject who had not solved trained on an inference task. The subjects were then told that one of them had received training on a task similar to that on which they now were to together, and that the experimentor was interested to see how well the trained subject could tell his partner about his own policy and the extent to which the learner could learn from the more experienced subject.

When both subjects showed that they had understood the purpose of the experiment, they were required to go through 60 trials on an inductive inference task together according to the following procedure. On each trial, both subjects first (1) made individual predictions of the criterion which they recorded on a special form. They then (2) showed the prediction to each other and if the predictions differed, they (3) discussed the case until (4) they could agree on a joint prediction which they (5) told the experimentor. After this they (6) made a second private prediction on a second form before they finally turned the page to observe the criterion value.

Those assigned to the TL control condition solved the experimental task individually according to the same standard procedure as that followed by the teachers in their training stage.

RESULTS

Data analysis. Only the first response made on each trial was used in the analyses. Tucher's (1964), see Eq. 1, version of the lens model equation was used to analyse these responses

$$r_a = G R_e R_s \qquad (1)$$

where r_a is the correlation between the subject's responses and the criterion value, G is the correlation between the linearly predictable variance in the task system and that in the subject's response system, R_e is the multiple correlation between the cues and the criterion, and R_s is the multiple correlation between the cues and the subject's responses. r_a is called the "achievement index" and shows the extent to which the subject is able to predict the criterion values. G shows the extent to which the systematic features of the subject's cognitive system match the systematic features of the task system. R_s, the consistency index, shows the extent to which the subject uses the same policy from trial to trial. R_e, defines task predictability, and shows the upper limit for achievement, for if the subject has perfect knowledge about the task (G = 1) and if he applies it consistently (R_s = 1), then $r_a = R_e$.

In addition to r_a, G, and R_s, the correlation between each cue and the subject's responses was computed. Since the cues are uncorrelated, these coefficients indicate the weight given to each cue by the subject. Before computing the correlations for the non-linear task the cue-response relations were transformed to linear form, using the same transformation as that required to linearile the cue-criterion relations. The 60 trials were divided into four blocks with 15 trials in each block, and all indices were computed for each block and subject. The correlation coefficients were transformed to Fischer's Z-scores before the statistical analysis. The consistency index R_s was squared before analysis.

A 3 (learning conditions: IPL-teacher vs. IPL vs. TL) by 2 (learning tasks: linear vs. non-linear) by 4 (blocks of learning) ANOVA with repeated measures on the last factor was made for each index.

Achievement, r_a. The ANOVA yielded significant main effects of learning tasks, learning conditions, and blocks ($F\ 1/42 = 41.38$, $p < .01$, $F\ 2/42 = 19.73$, $p < .01$ and $F\ 3/126 = 8.73$, $p < .01$, respectively). A significant learning conditions by blocks interaction were also found. ($F\ 6/126 = 2.94$, $p < .05$). The other interactions e.g., the learning tasks by blocks interaction and the learning tasks by learning conditions by blocks of learning interactions reached however only borderline significance ($F\ 3/42 = 2.65$, $p < .06$ and $F\ 6/126 = 1.85$, $p < .10$, respectively). Figure 1 shows these results.

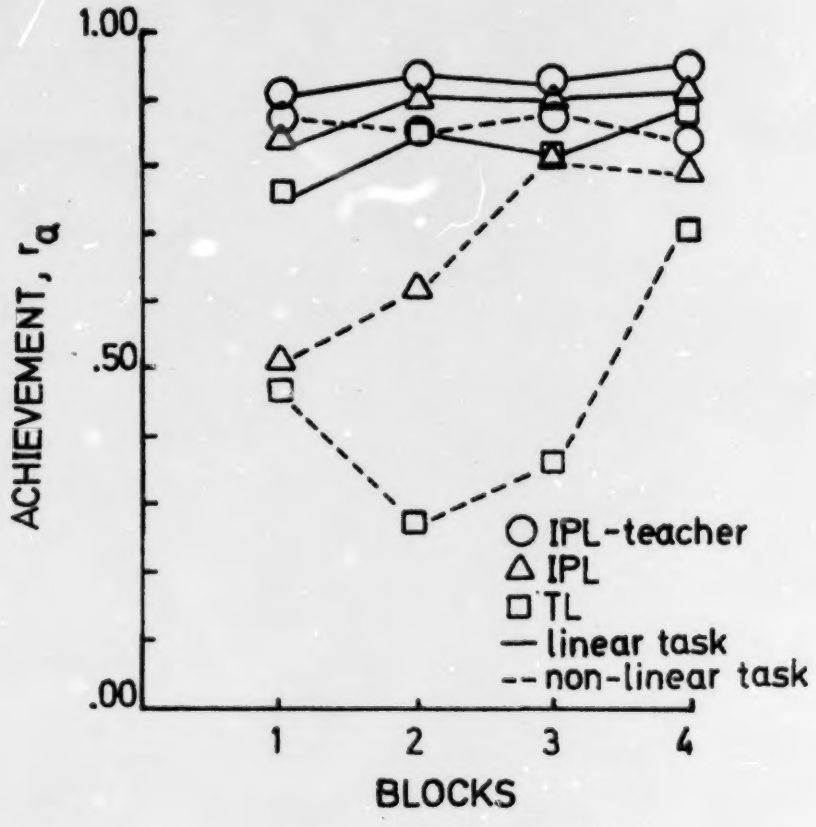

Figure 1. Achievement, r_a, as a function of blocks for linear and non-linear subjects in the interpersonal learning, teacher, (IPL-teacher), the interpersonal learning (IPL) and the individual task learning (TL) conditions.

In this figure, we can see that subjects learned the linear task better than the non-linear tasks in all learning conditions. We can also see that the teachers had the highest level of achivement and that the IPL subjects were better than those in the TL-conditions, who had the lowest level of achievement.

The results therefore show beneficial effects of interpersonal learning as compared to the task learning (TL) conditions for both tasks. Post hoc comparisons with the Newmann-Keuls method reveals that the difference between the TL and the IPL conditions was significant ($p < .05$) for the non-linear subjects and that it reached a borderline significance ($p < .10$) for the linear subjects. This agrees with the prediction that subjects learning a non-linear task will benefit more from IPL than subjects learning a linear task.

The results also show, however, that interpersonal learning not is optimal: IPL subjects have a lower level of achievement than their teachers in both tasks, but the differences are greater in the non-linear conditions than in the linear conditions. Post hoc comparisons show a significant difference between the teachers and the IPL subjects in the non-linear condition, but for the linear conditions the difference does not exceed the chance level. This agrees with the prediction that teachers with non-linear policies will be able to teach less of what they know than teachers with linear policies.

To examine this problem more closely the achievement of the IPL subjects relative to that of their teachers was computed for both task conditions as the ratio of the learner's r_a to the teacher's r_a. The difference between the linear and the non-linear condition was then analyzed by means of a t-test for each block. The results are shown in Table 1.

Table 1. Relative achievement (r_a/r_a) for subjects in the interpersonal learning (IPL) conditions compared to their teachers for subjects in the linear and the non-linear conditions.

Blocks	Linear task	Non-linear task	t	p
1	.94	.58	5.29	.0005
2	.98	.75	3.03	.005
3	.98	.92	2.00	.05
4	.99	.99	0.00	0.00

The table clearly shows that it takes the non-linear subjects longer than the linear subjects to reach the same level of achievement as their teachers.

Consistency, R^2_s. The results are shown in Figure 2. As can be seen from the figure, the linear subjects are more consistent than the non-linear subjects ($F\ 4/142 = 59.97$, $p < .01$). The order among the learning conditions is the same as for achievement with the teachers showing the highest level of consistency followed by the IPL subjects and with the TL subjects having the lowest level of consistency. ($F\ 2/42 = 24.57$, $p < .01$). Significant blocks effects were also found ($F\ 3/126 = 19.35$, $p < .01$), but these blocks effects are due to improvements only for the subjects in the IPL and the TL-conditions as confirmed by the significant learning conditions by blocks interactions ($F\ 6/126 = 4.68$, $p < .01$). The teachers in both task conditions perform at a stable level throughout the interpersonal learning stage, and do not improve.

For this reason also the significant learning tasks by learning conditions and learning tasks by blocks interactions ($F\ 2/42 = 3.56$, $p < .05$ and $F\ 3/126 = 4.68$, $p < .01$ respectively), must

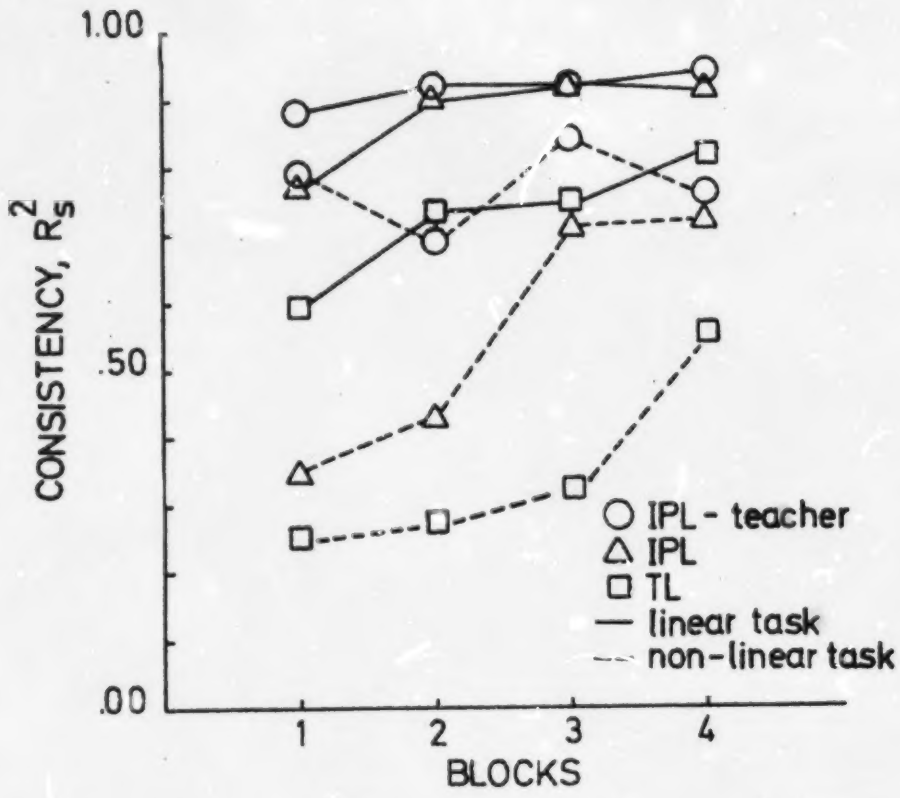

Figure 2. Consistency, R_s^2, as a function of blocks for linear and non-linear subjects in the interpersonal learning, teacher, (IPL-teacher), the interpersonal learning (IPL) and the individual task learning (TL) conditions.

be interpreted as differences in amount and rate of learning for IPL and TL subjects in the two kinds of tasks. From Figure 2 we can see that the rate of improvement is lower for the non-linear subjects in both the TL and the IPL conditions. Furthermore, we can see that there is almost no difference in consistency between the IPL subjects and the teachers in the linear task condition. In the non-linear condition, on the other hand, IPL subjects show much lower consistency than their teachers. Post hoc comparisons with the Newman-Keuls method confirm these interpretations. They show that the difference is significant ($p < .01$)

in the non-linear case but not it in the linear case. The three-way learning tasks by learning conditions by blocks interaction was only a marginally significant, however ($F\ 6/126 = 2.00$, $p < .10$).

Matching, G. Main effects of tasks and learning conditions were found ($F\ 1/42 = 7.13$, $p < .05$ and $F\ 2/42 = 9.32$, $p < .01$, respectively). The linear subjects learned the correct cue weights faster and the rank order among the learning conditions with respect to G was the same as that for achievement and consistency, namely that the teachers' cue weights were most optimal followed by those for the IPL subjects and these for the TL subjects in that order. A significant learning conditions by blocks interaction ($F\ 6/126 = 3.24$, $p < .01$) was due to the fact that the subjects in the non-linear task learning (TL) condition, had a considerably lower level of matching in the second an the third block then the subjects in the other learning conditions, as confirmed by the results of Newman-Keuls tests.

Cue dependency, left cue. Main effects of tasks, learning conditions and blocks were found ($F\ 1/42 = 27.03$, $p < .01$, $F\ 2/42 = 19.65$, $p < .01$, and $F\ 3/126 = 4.76$, $p < .01$, respectively), as well as a significant learning tasks by learning conditions interactions ($F\ 2/42 = 6.98$, $p < .01$).

The main effect of learning conditions parallels the results for the other measures of performance in that teachers have the highest scores followed by the IPL subjects. The lowest scores are found for the subjects in the TL-conditions. This is true both for linear and non-linear tasks.

In Figure 3 we can see, however, that there are no differences between the teachers in their dependency on this cue and also that their cue dependency is the same in all blocks. This means that main effects of tasks is caused by difference in learning among subjects in the IPL and TL-conditions as indicated by the learning tasks by learning conditions interaction. While subjects

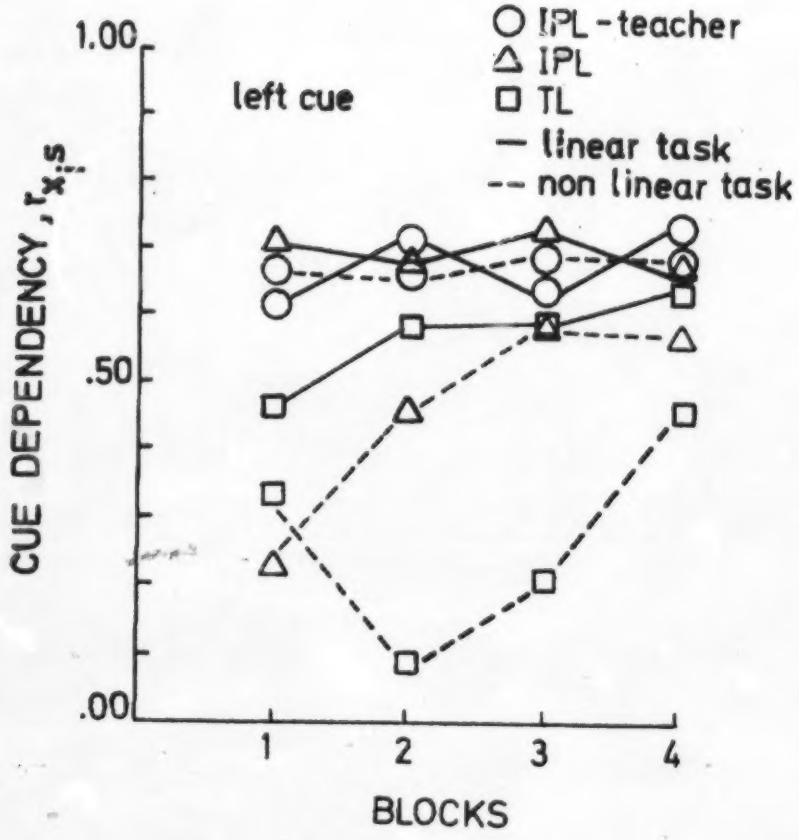

Figure 3. Cue-dependency, r_{yis}, as a function of blocks for linear and non-linear subjects in the interpersonal learning, teacher, (IPL-teacher), the interpersonal learning (IPL) and the individual task learning (TL) conditions.

in the linear IPL-condition show evidence of almost instantaneous learning those in the non-linear IPL-conditions only gradually aquire a dependency that exceeds the chance level (the 5 % level requires an r of about .50). With respect to the rate of learning, IPL is thus not as good for a non-linear task as for a linear task.

Similar differences can be seen for subjects in the TL-conditions. Not until the last block do the subjects in the non-linear condition reach the level of cue dependency achieved by the subjects in the linear condition already in the first block. Post hoc comparisons with the Newman-Keuls method show that the linear IPL subjects in fact have a slightly higher cue dependency than the teachers and also that they have a significantly ($p < .05$) higher cue-dependency than those in the TL-condition. For the non-linear task subjects in the IPL-condition had significantly lower cue-dependencies than their teachers. They did however, show a significantly higher cue-dependency than those in the TL-condition.

Cue dependency, right cue. Main effects for tasks, learning conditions and blocks were found ($F\ 1/42 = 44.74$, $p < .01$, $F\ 2/42 = 10.15$, $p < .01$, and $F\ 3/126 = 4.42$, $p < .01$ respectively). The learning tasks by learning conditions interaction and the learning condition by blocks interaction both reached significance ($F\ 2/42 = 3.22$, $p < .05$, and $F\ 6/126 = 2.16$, $p < .05$, respectively). With two exceptions these results parallell those for the other cue. First, for this cue the non-linear teachers have a lower cue dependency than their linear colleques. Second, the non-linear IPL subjects have a fairly high dependency on this cue in the first block.

The main effects of learning tasks can therefore be attributed to a lower dependency on this cue for non-linear subjects in all learning conditions. The significant learning tasks by learning conditions interaction is caused by the low level of dependency for this cue among the non-linear subjects in the TL-condition. Post hoc comparisons with the Newman-Keuls method-support this in that there were no differences among the learning conditions for the linear task. For the non-linear task, no difference was

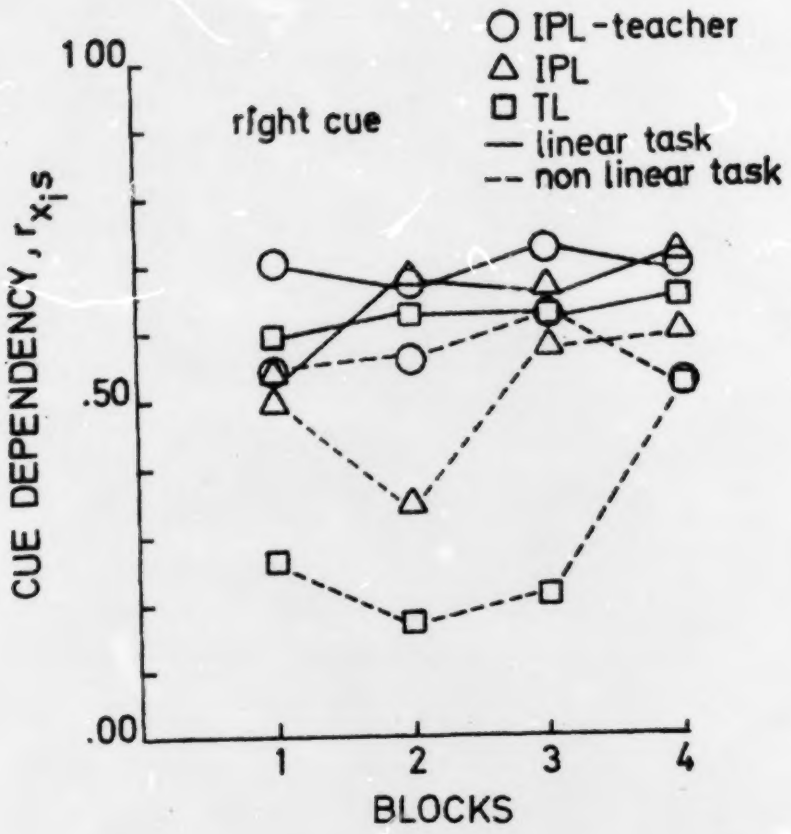

Figure 4. Cue-dependency, $r_{x_i s}$, as a function of blocks for linear and non-linear subjects in the interpersonal learning, teacher, (IPL-teacher), the interpersonal learning (IPL) and the individual task learning (TL) conditions.

found between the teachers and the IPL subjects. The subjects in the TL-condition had significantly lower cue dependencies than those in the other learning conditions.

The learning conditions by blocks interactions can be attributed to improvements for the subjects in the IPL and TL-conditions since the teachers in both task conditions have a stable level of cue dependency in all blocks of learning.

DISCUSSION

The results of this experiment support both of the hypothesis for the study in that (a) performance in the IPL conditions is relatively much higher than that for the individual learning conditions for the nonlinear task, and (b) the learners approach the same level of performance as their teachers at a much slower rate in the nonlinear IPL conditions than in the linear IPL conditions. In the latter conditions, teachers and learners have the same level of performance in the very first block.

That IPL would be more superior to individual learning for non-linear tasks was expected from earlier IPL studies. Earle (1973) compared IPL and dyadic task learning, a situation in which two subjects who did not know the task had to learn either a linear or a non-linear cue. He found that whereas subjects in the dyadic condition learned to use the linear cue as fast as those in the IPL condition. Only subjects in the IPL condition learned the nonlinear cue.

Recent results (Andersson & Brehmer, 1977 d) have shown, however, that dyadic tasks learning leads to lower performance than individual learning, presumably because subjects suffer a loss of cognitive control in dyadic task learning because of their erratic communication. Therefore, we do not know whether Earle's results should be interpreted to mean that IPL is superior, or that they just show that dyadic task learning conditions are detrimental to learning. The present results, on the other hand, give clear evidence that IPL is superior, and that its superiority is greater for non-linear tasks than for linear tasks, because the control group used here provides a more adequate baseline, and support the conclusion that IPL lead to better performance because the subjects are able to teach eachother something important about the task. This conclusion is supported by the fact that IPL is best

in the non-linear conditions, i.e., the conditions hardest in individual learning because the subjects cannot find the rule for the task on their own (see Brehmer, 1974).

The present results differ from those of Earle (1973) in that positive effects of IPL are obtained, not only for non-linear tasks, but also for linear tasks. This is presumably due to the fact that we used a well defined IPL situation in which the subjects know from the very start who could learn from whom. Thus, they did not have to spend time to find out who had anything to contribute, and, the learners could take advantage of their teachers' knowledge also in the linear conditions.

However, even though we find that the IPL effects are greatest for the non-linear tasks, we also find that the teachers are relatively less efficient in these conditions. Specifically, we find that the learners approach the same level of performance as their teachers at a much slower rate in the non-linear conditions than in the linear conditions. To explain this result, we have to consider two earlier findings. First, it has been shown (Brehmer, et al., 1974) that subjects have greater problems in describing their policies accurately when these policies are non-linear than when they are linear. Consequently, we have to assume that the teachers were not able to describe their policies to the learners as efficiently in the non-linear conditions as in the linear conditions. That is, they simply could not teach all they know.

Second, non-linear policies are harder to use than linear policies (Brehmer, 1977; Deane, Hammond & Summers, 1972). Therefore, the subjects in the non-linear conditions probably could not use the information given to them by their teachers as efficiently in the non-linear conditions as in the linear conditions. That is, they could not learn all their teachers had to teach.

Thus we find that two factors prevent teachers to transmit all their knowledge: (a) They cannot describe what they know, i.e., their descriptive knowledge is less accurate than their predictive knowledge, and (b) the learners cannot use all that their teachers tell them, i.e., the learners cannot transform their descriptive knowledge into predictive knowledge immediately.

The design of the present experiment does not make it possible to assess the relative weight of these two factors. To do so is one of the most important tasks for future studies in the area.

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